

TECHNOLOGY UTILIZATION

**CASE FILE  
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COMPUTER PROGRAMS:  
INFORMATION RETRIEVAL AND DATA ANALYSIS

A COMPILATION



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

# Foreword

The National Aeronautics and Space Administration and the Atomic Energy Commission have established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of their research and development, NASA and AEC earn for the public an increased return on the investment in aerospace research and development programs.

The items presented in this compilation are divided into two sections. Section one treats of computer usage devoted to the retrieval of information that affords the user rapid entry into voluminous collections of data on a selective basis. Section two is a more generalized collection of computer options for the user who needs to take such data and reduce it to an analytical study within a specific discipline. These programs, routines, and subroutines should prove useful to users who do not have access to more sophisticated and expensive computer software.

Additional information on individual items can be requested by circling the appropriate number on the Reader Service Card included in this compilation; or from: COSMIC, 112 Barrow Hall, University of Georgia, Athens, Georgia 30601.

Unless otherwise stated, NASA contemplates no patent action on the technology described.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

Jeffrey T. Hamilton, Director  
*Technology Utilization Office*  
*National Aeronautics and Space Administration*

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# Section 1. Information Retrieval

## DISPLAY REQUEST CHECKOUT

This program is designed to display the contents of the four words constituting a display request interrupt, so as to be useful in hardware checkout of the GE-635 computer.

When a display request interrupt occurs, the four words which constitute the request are accepted by the display adapter. The first of the four words is placed into the display adapter buffer register, interrupting the RT-10C to obtain a store cycle of memory. Upon completion of the store cycle, the memory issues an answer strobe which is sent to the display adapter. Here the strobe is converted into a computer ready pulse which invites the display subsystem to transmit the next word of the display request message. The second and third words of the display request message are handled in the same manner as the first word. The final (fourth) word is handled differently in that the memory answer strobe resulting from this word is not converted into a computer ready pulse. Instead, the display adapter requests the RT-10C to set a program execute interrupt cell in the computer memory module. The interrupt handler routine, which responds to this execute interrupt, interprets it to mean that a display request has been received. The

handler then moves the four words of the request out of the memory buffer area so that it may be interpreted by the display program.

The first two words contain the contents of the 10-character data select panel on the display console; word three contains the GMT of the desired display start time. Word four contains the plot grid time span in seconds, and the device identification. All characters are BCD representations. The program places each of these characters in bits, 24-29 of a list of display data, the starting address of which is specified by the DCW pointer contained in that particular write display command, and displays the four words exactly as received from the interrupt handler. The device identification bits are stored in the display data list, thereby directing the output to the appropriate display console.

This program is written in FORTRAN IV (10%) and GMAP (90%) for use with the GE-635 computer.

Source: Kennedy Space Center  
(KSC-10434)

*Circle 1 on Reader Service Card*

## AUTOMATIC CHECKOUT EQUIPMENT COMPRESSED DATA DUMP PACKAGE

This program package consists of two dump programs. The input tape for each program is in ACE (Automatic Checkout Equipment) Compressed Data Tape format.

The first program is a compressed tape time slot dump program. It is designed to dump the values which appear on a compressed data tape, one prime frame at a time, with each value tagged by its time slot number. The program will dump from a given start time to a given stop time or, from a given start time, for a specified number of prime frames. This program is intended solely for use as a programmer's aid, or by data reduction for quality assurance check-

ing. It should not be used to dump large intervals of data.

The second program can be used to dump and/or copy tapes. There are three types of dumps which can be obtained. The first type is a straight octal dump. This dumps, in byte pairs, all entries on the input tape. Loss of syncs, stagings, and parity errors are noted. The user must decode this dump for his own use. The second type of dump is an analytic dump, and is broken into two parts. First is a straight octal dump of the first ten records, next is an analysis dump of the remaining records. This analysis indicates record numbers, loss of sync, staging, parity, blank records,

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and end of file. The third type dumps out only the tags and associated data that are specified by the requestor.

This program is written in FORTRAN IV (26%)

and GMAP (74%) for use with the GE-635 computer.

Source: Kennedy Space Center  
(KSC-10454)

*Circle 2 on Reader Service Card*

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### FILING/RETRIEVAL SYSTEM FOR HISTORICAL EVENTS

This system consists of data documentation, filing, and retrieval and reduces the time and cost of building up and maintaining a detailed chronological listing of historical events and related reference information. The system was developed around a specially designed Historical Event Information Card. The card permits both manual and computer filing and retrieval of historical data. Filing is done by date of event, while retrieval can be made by either date of event or by the event's relevance to a combination of factors such as program, contract, project, product number, system, structure, activity, location, or management organi-

zation. The computer program automates the filing and retrieval effort. Users of the system can develop their own retrieval codes according to need from guide lines given in the detailed description of the system.

This program is written in COBOL language for use with the IBM-360, Model 65, Release 11 computer.

Source: North American Rockwell Corp.

under contract to  
Marshall Space Flight Center  
(MFS-16155)

*Circle 3 on Reader Service Card*

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### SCHEDULES DOCUMENT SYSTEM

Schedules Document System is a series of sub-programs under executive control of a main program which automatically produces schedule reports in finished document form. The system is capable of processing single or multiple projects consisting of a variable number of events and items for which schedules are computed. A tape and/or drum master file can be modified by merging the appropriate portion with card input. Each time any section of the master file is updated, new schedule dates are computed. A unique date routine allows schedule date calculations based upon either work day flow or actual day flow. One of the optional output formats is a graphical 8-1/2 x 11 inch display, providing computed schedule dates in a matrix format.

In addition to the advantage of applying automated techniques to previous manual efforts, the Schedules Document System incorporates the following unique

features: (1) calendar to Julian date conversion routine; (2) Julian to calendar date conversion routine; (3) override feature allowing exceptions to computed dates; (4) user supplied table of up to 15 holidays per year for a maximum of 20 years; (5) "temporary run" feature allowing a total project scheduling visibility for feasibility studies; (6) automatic masterfile guard made when using "temporary run" option; (7) immediate recomputation and display of schedule dates following any project changes.

This program is written in FORTRAN V language for use with the UNIVAC-1108 EXEC-V111 computer.

Source: The Boeing Company

under contract to  
Marshall Space Flight Center  
(MFS-20834)

*Circle 4 on Reader Service Card*

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## PROGRAM PRINT

This program was initiated for the Master Electrical Equipment List (Library) which contains descriptive data for each component part of the CSM (Apollo) which uses electric power. It was designed to facilitate preparation of the list. The data are keypunched from forms and printed with a SC-4020 plotter in a double frame typewriter mode. Naturally, it can be used in other systems where lists of data are to be kept and it is desired that updates, additions, insertions and corrections be more easily and neatly completed than if done using a typewriter. However, data to be printed must conform to the column limitations as set forth in the special work sheet forms. Since PRINT outputs

data on a CRT frame, the method allows more characters per page than a typewriter; and, since data is contained on cards, corrections are easily accomplished, and computer turn-around time is quicker and cheaper than typing time.

This program is written in FORTRAN IV language for use with the IBM-7094 computer and SC-4020 plotter.

Source: North American Rockwell Corp.  
under contract to  
Manned Spacecraft Center  
(MSC-15213)

*Circle 5 on Reader Service Card*

## INFORMATION RETRIEVAL SYSTEM

This generalized information retrieval system generates and maintains a file, gathers statistics, sorts output, and generates final reports.

The system is useful in the usual applications involving administrative data and document information, and also in applications involving purely numerical engineering data. In order to use any retrieval system on an aggregate of information elements, the aggregate must first be given some structure which will make possible the computer recognition of each element. Such a structured aggregate is called a file. There are two general types of files: a fixed file, in which the exact location of each information element is predetermined; and a variable file, in which the location of an information element depends on the size of every element and on the total number of elements. The system makes use of a variable file and admits an arbitrary number of information elements of arbitrary size. This flexibility gives the user great ease in changing, adding, or deleting information anywhere in a file.

The file generation and file maintenance programs which have been written for the system are general purpose routines. Engineering or administrative data might be the input or output of a mathematical

computer program.

After a file has been generated or searched, the results must be presented to the user. The system is very flexible in the choice of format of the printed output. For example, the user may suppress specific information, specify column and row headings, or request special text formats.

In addition to the basic function of being able to search a file for specific information, the system has the capacity for sorting the output in a prescribed manner. Furthermore, while a file is being searched, simple arithmetic operators may be applied to specified numerical information in the file, accomplishing a tabulation of one or more functions from document to document.

This program is written in FORTRAN IV language for use with the IBM-7040-44 Computer System.

Source: D. A. Levine, C. Mee III, E. A. Kelroy,  
R. F. Berg, and J. E. Holcomb of  
Bellcomm, Inc.  
under contract to  
NASA Headquarters  
(HQN-10426)

*Circle 6 on Reader Service Card*

## Section 2. Data Analysis

### THEORETICAL RADAR ACCURACY

Any observed errors in azimuth, elevation, and range data from a radar are propagated to any reference frame to which the data may be transformed. Whenever the transformations involved are nonunitary, the errors propagated are a function of the transformation, and therefore are not uniformly distributed. This condition is known as Geometric Dilution of Precision and the resultant errors are commonly called GDOP's.

This Theoretical Radar Accuracy Program (TRAPI) is designed to compute the expected GDOP's in each of three Cartesian position coordinates that result from system errors in observing azimuth, elevation, and range.

The Cartesian system used is right-handed with the downrange axis directed at some azimuth  $\alpha$  with respect to north; the crossrange axis is directed at an azimuth of  $\alpha + 90$  degrees. The downrange-crossrange plane is tangent to the spheroid at the origin of the Cartesian system. The system is completed by the axis normal to the downrange-crossrange plane at the origin. There is an option to use the Apollo Standard Coordinate System (ASCS) which will include special labeling of the various output variables and pertinent constants.

A minimum of one and a maximum of 20 radars may be input to the program. The number of input radars is used to index computations. Additional input consists of the following: spheroid data, coordinate system location and orientation, radar locations and accuracies, and Cartesian position data.

The output data include a binary tape that contains time and the coordinate GDOP's in each record, and a printed tabular copy containing time and the coordinate GDOP's on each printed line.

The only error message output by the program occurs whenever all of the input radars are viewing the vehicle below an input lower-elevation-limit. The message indicates that no solution is possible at the time point being processed. This elevation criterion feature also acts to exclude any station viewing the vehicle at an elevation below the limit from participating in the solution.

This program is written in FORTRAN IV language for use with the GE-635 computer.

Source: Kennedy Space Center  
(KSC-10430)

*Circle 7 on Reader Service Card*

### ANALYSIS OF FLOW ACROSS A ROTATING SEALING DAM

Some advanced jet engines exceed the operating limits of conventional face contact seals. As a result, noncontacting face seals are becoming necessary to avoid high leakage rates associated with labyrinth seals. Effects of relative rotation of the sealing dam surfaces on the radial pressure flow are not presently covered in the literature.

A computer program has been developed which, by means of a mathematical model, analyzes the flow across the parallel sealing dam of a shaft face seal. The analysis covers steady, laminar, subsonic, isothermal compressible flow with rotation of one of the sealing dam surfaces. The effect of rotation on mass flow, pressure distribution, and other physical parameters

is determined. The automatic calculation and print-out of physical variables aids in achieving good design.

Input variables include the dimensions of the seal, pressure boundary conditions, and the molecular weight and physical properties of the gas. The output includes mass flow rate, pressure and velocity distribution, Mach number, force, center of pressure, rotational flow Reynolds number, pressure flow Reynolds number, power loss, torque, and approximate temperature rise due to viscous shearing for specified film thicknesses.

The program is written in FORTRAN IV for use with the IBM-7094/7044 computer.

The following documentation is available from:  
National Technical Information Service  
Springfield, Virginia 22151  
(Microfiche price \$0.95)

Reference: NASA TN-D-5344 (N69-35799)  
Investigation of Isothermal, Compressible  
Flow Across a Rotating Sealing Dam-- I --  
Analysis (Single document \$6.00)

NASA TN-D-5345 (N71-21434) Investigation  
of Isothermal, Compressible Flow Across a  
Rotating Sealing Dam --II--Computer Program  
(Single document \$3.00)

Source: J. Zuk, P. J. Smith, and L. P. Ludwig  
Lewis Research Center  
(LEW-11033)

*Circle 8 on Reader Service Card*

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## ANALYSIS OF DYNAMICS OF A TURBINE-DRIVEN BOOST PUMP

The fluid and machine dynamics of an inducer pump with full-flow, full-admission hydraulic turbine and the piping systems in which it operates, are described for digital computer FORTRAN IV programs formulated for use with the IBM 360 Model 65 or 67 computers. Programs are written which describe closed-loop test facilities and open-ended propellant feed systems. Components common to the two systems are written in subroutine form.

The inducer dynamic performance is modeled by describing the performance of the individual blade rows (i.e., inducer, rotor, and turbine) using normalized curves which are obtained from blade and passage designs. The performance curves are mono-, bi-, or tri-variant functions. The equations describing the work balance on the shafts, the boundary conditions, the energy (heat) balance, and minor flow losses complete the model. One subroutine was written to handle all blade rows by inclusion of appropriate tests and optimization subroutines.

The piping system model is composed of subroutines which describe the system components---lines, valves, joints, recirculation lines, and orifices---using a finite difference method of characteristics solution

to the basic equations for unsteady flow through conduits (commonly called waterhammer equations).

The following documentation may be obtained from:

National Technical Information Service  
Springfield, Virginia 22151  
Single document price \$6.00  
(or microfiche \$0.95)

Reference: NASA CR-72566 (N69-34962)  
Inducer Dynamics Full-Flow, Full-Admission  
Hydraulic Turbine Drive.

Source: G. K. Olson, J. F. Farquhar, J. Chan  
and R. H. Marler of  
Aerojet-General Corp.  
under contract to  
Lewis Research Center  
(LEW-11077)

*Circle 9 on Reader Service Card*

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## PROGRAM ANALYZES STATIONARY OUTSIDE-COIL LUNDELL ALTERNATORS

A digital computer program has been developed for analyzing the electromagnetic design of stationary, outside-coil Lundell alternators. This program can be used for parametric studies and alternator design optimization. The program accepts as input, a complete electromagnetic alternator design; from this, it cal-

culates the open-circuit saturation curve, field-current requirements at rated voltage for various loads, losses and efficiency, several reactances, and weights of electromagnetic components. The results of the calculations, together with the input, are then printed out to provide a complete, self-explanatory record.

The program may be used with any computer system which accepts FORTRAN IV.

The following documentation may be obtained from:

National Technical Information Service  
Springfield, Virginia 22151  
Single document price \$3.00  
(or microfiche \$0.95)

Reference: NASA TN D-5814 (N70-28433)  
Description and Evaluation of Digital-Computer Program for Analysis of Stationary Outside-Coil Lundell Alternators.

Source: G. Bollenbacher  
Lewis Research Center  
(LEW-11081)

*Circle 10 on Reader Service Card*

## TANK MODE ANALYSIS

The purpose of this program is to calculate the axisymmetric longitudinal mode shapes and frequencies of thin shells of revolution, partially filled with an incompressible fluid and containing a pressurized gas in the remaining volume. This shell may have fixed, free, or sprung degrees of freedom as well as lumped masses at each node. The need for such a program becomes apparent when one considers the development of large launch vehicles consisting largely of liquid propellants in thin elastic tanks. Present lumped-mass analyses become totally inadequate. The areas of concern include both transient loads such as occur during thrust buildup and vehicle release as well as the possibility of coupled structure-fluid-thrust instability.

The shell must be single walled and idealized by no more than 29 individual elements bounded by 30 nodal lines or stations. The maximum number of

mode shapes is restricted to the order of the influence matrix. Further, the order of the influence matrix is internally calculated from the shell and fluid geometry. Hence the program has been written to calculate any number of mode shapes, up to and including the order of the matrix.

This program is written in two versions. Version one is written in FORTRAN IV (98%) and MAP (2%) for use with the IBM-7094 computer. Version two is written in FORTRAN IV for use with the IBM-360, Release 11 computer.

Source: The Boeing Company  
under contract to  
Marshall Space Flight Center  
(MFS-15135)

*Circle 11 on Reader Service Card*

## BOTTLE BLOWDOWN ANALYSIS

The purpose of the Bottle Blowdown Analysis program is to study the thermodynamics of a pressurant in a storage bottle. The pressure, temperature, and flow into or out of a bottle during fill, drain, or standby is computed. Provision is made for deviation from the perfect gas equation of state. The bottle wall is divided into a number of slabs and a one dimensional heat transfer analysis is performed. The bottle may or may not be shrouded with a cooling jacket; if no jacket is present, the bottle environment must be definable. The two cases are also identical, the principal difference being that the coolant boil-off rate is of interest in the case of a jacketed container.

The main program does little except input and output and determining which method of computing flow rates is to be used. The actual solutions are obtained by various subroutines.

At the specified time intervals the values of bottle pressure and temperature, amount of pressurant in the bottle, and wall temperature are output. A flow rate into and out of the bottle, the coolant boiloff rate, and the outside film coefficient are also printed.

It is assumed that the outside environment of the bottle is uniform. It is also assumed that flow into or out of the bottle via a piping system is adiabatic. The program requires considerable time when the flow

rate into or out of the bottle is computed through a piping system.

This program is written in FORTRAN H language for use with the IBM-360, Release 11 Computer.

Source: The Boeing Company  
under contract to  
Marshall Space Flight Center  
(MFS-15152)

*Circle 12 on Reader Service Card.*

## ANALYSIS OF FLOW THROUGH TURBINES

This is a method of analyzing flow through a turbomachine (turbine, compressor, or pump) that is readily adaptable to computer programming. Previous methods obtained a two-dimensional solution based on an equation for the velocity gradient along the normal to the projection of the streamlines on a plane containing the axis of rotation (the meridional plane). The meridional streamlines and their normals are used to establish a grid for a meridional-plane solution. In cases where the distance between the hub and shroud is great and there is a large change in flow direction within the rotor, the normals vary considerably in length and in direction during the course of the calculations; therefore, it is difficult to obtain a direct solution on the computer without resorting to intermediate graphical steps.

This new method obtains a direct solution by the use of arbitrary curves (called quasi-orthogonals) from hub to shroud, instead of streamline normals. The quasi-orthogonals are not necessarily orthogonal to each streamline but intersect every streamline once across the width of the passage. The quasi-orthogonals remain fixed regardless of any change in streamlines. Using this technique, a computer program is developed that calculates a streamline solution in the meridional plane without any intermediate graphical procedures, even for turbomachines with wide passages and a change in direction from radial to axial within the rotor blade.

From the meridional solution, it is possible to obtain blade-surface velocities by several methods. A method which gives good results is a blade-to-blade

stream function solution. This solution can be obtained by a finite difference solution of the stream function partial differential equation, using information from the meridional quasi-orthogonal solution. The blade-to-blade finite difference solution can be obtained with axial, radial, or mixed flow and with a change in stream channel thickness in the through-flow direction. The flow must be essentially subsonic, but there may be locally supersonic flow. By obtaining several blade-to-blade solutions, a complete blade surface velocity distribution can be obtained.

The following documentation may be obtained from:

National Technical Information Service  
Springfield, Virginia 22151  
Single document price \$6.00  
(or microfiche \$0.95)

Reference: NASA TN-D-2546 (N65-12306)  
Use of Arbitrary Quasi-Orthogonals for Calculating Flow Distribution in the Meridional Plane of a Turbomachine; and NASA TN-D-5427 (N69-37521), FORTRAN Program for Calculating Transonic Velocities on a Blade-to-Blade Stream Surface of a Turbomachine.

Source: T. Katsanis  
Lewis Research Center  
(LEW-236)

*Circle 13 on Reader Service Card*

## DYNAMIC ANALYSIS OF STRUCTURES

A program has been designed to determine the response of a composite linear structure subjected to low frequency sinusoidal base motion of a restrained

structure, or low frequency sinusoidal forces at points of a free structure. Models of components (basic systems) in forms of geometry, normal modes, fre-

quencies, lumped masses, and elastic properties are also investigated.

Systems are developed from basic systems when the required compatibility with the composite is imposed. Operation is divided into five parts: (1) basic system processing, (2) system processing, (3) composite processing, (4) force response calculation, and (5) point acceleration and member stress calculation. Any adjacent parts of the program may be used in a single computer run.

*Basic System Processing:* (1) geometry, member properties, normal mode shapes, frequencies, and modal damping coefficients are read in; (2) rigid body modes, modes describing the independent motion of redundant supports (constraint modes), modes associated with concentrated loads at unrestrained points (attachment modes), and associated reactions are calculated, and (3) the modal matrix, mass matrix, stiffness matrix, and damping matrix are formed.

*System Processing:* (1) required compatibility is imposed, and (2) transformations from composite coordinates to system coordinates, mass stiffness, and damping matrices of composite are developed.

*Composite Processing:* (1) undamped eigenvalues and eigenvectors are found, (2) the transformation uncoupled coordinates to composite coordinates and the uncoupled combined mass and damping matrix are developed, and (3) point accelerations of un-

damped mode shapes are punched by the computer if desired.

*Response Calculation:* (1) the generalized forcing function matrix is formed, (2) response of given control points is calculated and plotted, and (3) composite system generalized displacements for frequencies which have the largest response are punched by the computer.

*Point Acceleration and Stress Calculation:* (1) point accelerations are calculated from composite system generalized displacements punched on cards and transformations saved on tape, (2) mass acceleration "forces," the associated static displacements and related accelerations, are calculated, and (3) member loads are found using the deflections associated with either modal accelerations or inertial loading.

Ingenuity is required in the use of the program primarily in defining realistic idealizations of the components.

This program is written in FORTRAN IV language for use with the IBM-7094 computer.

Source: R. M. Bamford of  
Caltech/JPL  
under contract to  
NASA Pasadena Office  
(NPO-10129)

Circle 14 on Reader Service Card

## RECTANGULAR FITTING STRESS ANALYSIS

A computer program has been designed to simulate specific bulkhead fitting by subjecting the desired geometric configuration to a membrane force, an external force, an external moment, an internal tank pressure, or any combination of the above. Forces and moments resulting from the above loads are considered as well as forces and moments imposed by geometric deformations.

This program generates a general model of bulkhead fittings for large storage tanks. A fitting is free-bodied at each point of discontinuity and is composed of the following segments: (1) the bulkhead on which the fitting is welded, (2) outer annular ring or inter-step between the bulkhead and the thickest part of the fitting, (3) inner annular ring (4) ring boss which serves as a rigid mount for line flanges, and (5) an internal or external cylinder bolted to the ring.

The theory of strain compatibility is utilized in writing the discontinuity equations, which represent relations between deflections and rotations of adjacent components of the fitting. The solutions to these equations are found by P. D. Crout's elimination method for solutions of linear simultaneous equations. The solutions are used to compute stresses and margins of safety for various components of the fitting.

This program is written in FORTRAN II language for use with the IBM-7094 computer.

Source: A. R. Bertrand of  
The Boeing Company  
under contract to  
Marshall Space Flight Center  
(MFS-13010)

Circle 15 on Reader Service Card

## BUCKLING OF SHELLS OF REVOLUTION WITH VARIOUS WALL CONSTRUCTIONS

A computer program (entitled BOSOR) has been developed to perform stability analyses for a wide class of shells without unduly restrictive approximations. The program uses numerical integration and finite difference techniques to solve, with reasonable accuracy, a wide variety of buckling problems for shells of revolution which have "orthotropic" properties, oriented with principal axes in the axial and circumferential directions. For this type of shell in the prebuckling state, axisymmetric loads produce axisymmetric displacements. The program performs a nonlinear axisymmetric prebuckling analysis and then solves an eigenvalue problem to determine buckling loads.

For the geometry of the meridian, the general branch of the program calls for input in the form of Cartesian coordinates for a number of points along the meridian. Special branches are provided for cylindrical, conical, spherical, and toroidal shells.

The general branch for the shell wall stiffness data calls for input in the form of coefficients of the constitutive equations. Special branches calling for simpler input data are provided: shells with ring and stringer stiffening; shells with skew stiffeners; fiber reinforced shells; layered shells; corrugated ring stiffened shells; and shells with one corrugated and one smooth skin. The eccentricity of the stiffening is accounted for, but the stiffness coefficients must be constant along the meridian.

The most general form of the boundary conditions for the prebuckling analysis is a set of 4 nonhomogeneous equations containing 20 coefficients. For the stability analysis, the homogeneous boundary conditions consist of 8 equations with 64 coefficients which are called for as input by the general branch. The boundary conditions can be calculated internally (with only control integers required as input) by several branches provided in the program and include

force or displacement boundary conditions, support by elastic edge rings, or support by other elastic media. The shell can be open or closed at the apex. When the program makes use of the nonlinear prebuckling analysis, the boundary conditions for the prebuckling solution are consistent with the stability analysis.

In the first part of the analysis, the Newton-Raphson procedure is used to solve the set of nonlinear algebraic equations. These equations result from a finite-difference analog of the pair of nonlinear, nonhomogeneous, second-order ordinary differential equations governing the prebuckling state of the shell. The solution of the equations yields the prebuckling meridional rotation and meridional and circumferential stress resultants.

The second part of the analysis solves the stability equations (Donnell-type formulation) which are a pair of linear, homogeneous, fourth-order, partial differential equations having coefficients determined from the prebuckling analysis. Since the dependent variables are harmonic, dependence on the circumferential coordinate can be eliminated and the resulting ordinary differential equations solved by the method of finite differences. The stability analysis is formulated as an eigenvalue problem with the lowest eigenvalue of the stability equations corresponding to the critical load.

This program is written in FORTRAN IV for use with the IBM-7094 computer.

Source: D. Bushnell, B. O. Almroth, and  
L. H. Sobel of  
Lockheed Missiles and Space Co.  
under contract to  
Langley Research Center  
(LAR-10290)

*Circle 16 on Reader Service Card*

## ENGINEERING THERMAL ANALYZER (BETA II)

A single program called BETA II (Engineering Thermal Analyzer) uses numerical methods to provide accurate heat transfer solutions to a wide variety of heat flow problems. This highly versatile program will solve steady-state and transient problems in almost any situation that can be presented by a resistance-

capacitance network.

This new version of BETA increases its capabilities and broadens its options as well as making the program available to second generation computers such as the IBM-360.

Numerous analytical solutions are available for

problems with simple geometries, when the differential equations are linear. For more complex geometries, steady-state solutions may be obtained graphically or by experiment. Such methods are quite tedious and usually not applicable to transient analysis, yet the transient solution is usually needed to predict the thermal requirements in critical design areas.

The basic feature of this program and technique is the concept of the "lumped parameter network". The physical system under consideration is first broken down into a system of sections of "lumps". The mass of each lump is represented by a point or "node" somewhere within the lump, and the paths for the conduction of heat from one lump to another are represented by conductors connecting the appropriate nodes.

The Thermal Analyzer solves the network system using numerical methods. These methods involve an iterative process. Given a network with temperatures known at each node, it is possible, by applying a numerical equation, to predict a new value of the temperature at each node a short time later. This process of predicting new temperatures from old temperatures is repeated for many iterations until the problem is completed.

Two basic types of problems are possible: tran-

sient and steady-state. The operation of the Thermal Analyzer takes place in two phases, very much like two independent programs being executed in succession. The first phase is the Thermal Analyzer Compiler and the other phase is the Thermal Analyzer Executor. Since each phase is allocated and operated independently, only one phase is in core at any one time thus alleviating core size restrictions.

Both transient and steady-state solutions can be obtained for almost any system that can be represented by such a "lumped" network. This includes heat transfer problems involving conduction, convection, and radiation; mass transfer (diffusion) electrical circuits; and many other systems. Problems may be one-, two-, or three-dimensional, and may be nonlinear.

This program is written in FORTRAN H and BAL language for use with the IBM-360 system.

Source: J. H. Scates and L. L. Steinberg of  
The Boeing Company  
under contract to  
Marshall Space Flight Center  
(MFS-15055)

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## RELIABILITY ANALYSIS MODEL

The Reliability Analysis Model (RAM) program is an integrated Systems Design Analysis program whose primary capability combines the results of various analyses into a single effective and comprehensive program. The program can be readily applied to determine the probability of success for one or more given objectives in any complex system. RAM can be used to analyze transportation systems, traffic control systems, and to design more reliable and safer automobiles. Other applications can be directed toward urban planning, air pollution, water pollution, weather prediction, oceanographic exploration, determining the effect of weather on an environment, and the effect of human factors on reliability.

The RAM program includes failure mode and effects, criticality and reliability analyses, and some aspects of operations, safety, flight technology, system design engineering, and configuration analyses. The unique advantages of this methodology and its

associated programs are that the results of all these analyses are fed into a single data bank in terms of impact on mission objectives so that comparison, correlation, and tradeoffs may be made using the results of the various analyses.

The basic output of the program was first developed during the identification of those components that were critical to primary flight mission (no abort), vehicle integrity (no physical destruction of the vehicle), and crew safety. In addition to identifying those components that were critical to a specific objective, this program ranked objectives in order of importance (probability of causing loss). The program also provided estimates of the probability of primary flight mission success, vehicle integrity, and crew safety--both as an overall number and as a profile with respect to mission time.

The criticality determination (CD) technique used in conjunction with RAM, is a more general method

than those currently used. By this new method, criticality numbers can be assigned to components, sub-systems, systems, stages, missions and crews for any given failure distribution, such as the exponential, Weibull, gamma, or truncated normal, where applicable (Details of the CD technique were published in Tech Brief 68-10252.)

This program is written in COBOL for use with the

IBM-360/OS (optional) 8090-915 CDC Optical Scanner Computer.

Source: The Boeing Company  
under contract to  
Marshall Space Flight Center  
(MFS-14513)

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## FINITE ELEMENT THERMAL STRESS ANALYSIS OF PLANE OR AXISYMMETRIC SOLIDS

The FEATS computer code has been developed to obtain the following:

- (1) a two-dimensional steady state temperature distribution and the resulting thermal stress distribution in a plane or axisymmetric solid body, and
- (2) contour plots of the resulting distributions.

The FEATS computer code uses finite element analysis to calculate the steady state temperature and stress fields for either axisymmetric or plane two-dimensional bodies, including specified displacements, loads, and thermal boundary conditions.

The program was designed to be a general purpose code for solving linear and bi-linear stress-strain problems, thermal stress, and temperature fields. The program allows the calculation of temperature distributions for materials in which the thermal conductivity is a function of temperature. The code will also

calculate the axial stress in plane strain type bodies which are free to warp.

The code is available with capacities of up to 3000 nodal points and 2000 elements. A direct solution method which gives accurate results with computer time is used. The program is written in FORTRAN IV and Assembly languages for use on the IBM-360/75 or CDC-6600 computers.

Source: J. A. Swanson of  
Westinghouse Astronuclear Laboratory  
under contract to  
AEC-NASA Space Nuclear Systems Office  
(NUC-10242)

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## ROTORDYNAMIC RESPONSE ANALYSIS

A computer routine similar to Holzer's method in torsional vibration treatment, and Prohl's and Myklestad's approach in computing rotor deflection, is used to determine the dynamic rotor displacements and bearing reactions of a real rotor, with mass eccentricities, as functions of rotor spin speeds.

This program is applicable to the synchronous and axisymmetric motion of a rotor for up to 99 mass stations, supported by bearings having up to ten linear stiffness and damping characteristics. The program takes the following factors into consideration; flexible rotor couplings in shear and in bending; shear and bending elasticity of the rotor; rotor mass, and the

magnitudes and orientations of mass eccentricities; rotor polar and transverse moments of inertia; and rotor axial loading effects.

The output of the program, in both printout and CRT display, includes the absolute dynamic three-dimensional rotor mode shapes, the dynamic journal displacement, the bearing reactions, and the maximum rotor deflection, journal displacements and bearing reactions versus speed functions. Auxiliary outputs also available are the computed local and total rotor weight, computed local and total rotor polar mass moments of inertia, and the location of the center of gravity of the rotor.

The program is written in FORTRAN IV language for use with the IBM-ASP/360 system.

Source: F. A. Shen of  
North American Rockwell Corp.  
under contract to  
NASA Headquarters  
(HQN-10579)

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### MAPS-A MANAGEMENT ANALYSIS AND PLANNING SYSTEM

MAPS provides managers of large technical projects with a fast and economical information system for planning and controlling their projects. Input information on schedules and status is simultaneously submitted at all project levels and is automatically collated by the program, resulting in an easy-to-understand output.

The MAPS program is in essence a computerized bar chart schedule-reporting system in which the work structure of a project can be listed at all levels. This system integrates an item of work, its schedule, its status against the schedule, the person responsible for that item, and brief explanatory comments about the item. In addition, the relation of any single item to other items in the project is clearly shown by a hierarchical form of program organization. The structure of the MAPS program promotes a natural organization of all project work elements and can be used to control down to any level of detail desired.

A key feature of the MAPS program is that each project work element can be keyed to a responsible individual. This is true at all levels of the work structure. The program can give each individual a condensed listing on an item-by-item basis of the project work elements in his area of responsibility; thus, each individual can see exactly what his project role is and what schedule demands he is working against. This listing is also helpful to management in reviewing manpower requirements and loading.

Another key feature is that the MAPS system is written for fast updating. Thus, management review can always be conducted with up-to-date information.

The program has been found most effective when used in conjunction with a bi-weekly management review meeting; the printouts serving as both information and as a format from which to conduct the meeting. In the printouts, all new or updated information is identified as a change from the previous plan or schedule, which can be used as an exception reporting system. The information on the progress of each project element can be maintained on an exception reporting basis by individuals who are responsible for each work element listed.

Finally, the MAPS program is a resource saving tool. Experience to date on an R&D project involving over 100 professional personnel has shown that MAPS can be maintained on a detailed level by one operator utilizing about one-fourth of his time. The MAPS program is written so that no prior computer experience is required for an operator to effectively implement and maintain project computerized outputs.

MAPS has been specifically designed for planning and scheduling engineering project work; however, its flexible format capability permits a variety of other uses such as manpower and budget planning, configuration control, engineering work orders, drawing lists, parts lists, and others.

This program is written in FORTRAN IV language for use with the IBM-7094 computer.

Source: D. R. Packe and G. A. Raffaelli  
Lewis Research Center  
(LEW-11349)

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## ANALYSIS OF LOW RESOLUTION MASS SPECTRA

This computer program applies a recently developed spectral-analysis technique to the analysis of low-resolution mass spectra. Applications of this program include residual gas analysis for work in space environmental simulators, space environment contamination, and air pollution monitoring.

A pre-elimination process is used to compare the unknown sample spectrum with a reference library of standard spectra. A resulting running library is then utilized in a linear least-squares regression analysis of the unknown sample spectrum. A reference library of an unlimited number of standard spectra may be formed either from tables of mass spectra or other literature values, or generated by the user. A preprocessing section in the program screens out those reference library spectra whose base-peaks cannot contribute more than a specified minimum

amount to the unknown sample spectrum. The remaining library spectra form the running library for the analysis.

A "best-fit" of the running library spectra to the unknown sample spectrum is calculated using a linear least-squares regression technique. The amounts of those spectra contributing to the "best-fit" are the results of the analysis.

This program is written in FORTRAN IV for use with the IBM-360/91 computer and level-18 compiler.

Source: H. Shapiro  
Goddard Space Flight Center and  
R. W. Babst of  
Sperry Rand Corp.  
under contract to  
Goddard Space Flight Center  
(GSC-11279)

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## THERMAL ANALYSIS SYSTEM

The Thermal Analysis System program (TAS-1) combines a thermal analysis program with subprograms which compute the infrared conductance and the heat input due to solar heating.

The spectral analysis formulation is developed for two regions: a solar region in which solar properties apply, and an infrared (IR) region in which the IR properties apply. This separation is possible because there are two widely different temperature levels being considered: the high solar temperature, and the much lower spacecraft temperature. The solar region energy due to IR radiation is negligible in comparison with the solar energy itself. This widely used assumption makes it possible to compute the heat inputs in the solar region separately from the IR heat transfer. Thus, the heat inputs in the solar region are not a function of the spacecraft temperature. The problem solution is therefore reduced to that of finding the spacecraft temperature distribution for a single wavelength region, without the iteration procedures that

would be necessary for multiple regions.

Because the program is intended mainly as a design tool for the temperature control engineer, coding is simple and the input rules are easy to use and remember. The output format is easy to understand and to analyze for error diagnosis.

This program is written in FORTRAN IV and is operational on the IBM-7094, IBM-360/65, UNIVAC-1108 (EXEC 2), UNIVAC-1108 (EXC 8), and CDC-6400. The COSMIC version has executive control cards for operation on an IBM-7094, and these must be changed for use on the other machines.

Source: J. A. Hultberg of  
Caltech/JPL and  
P. F. O'Brien of  
University of California  
under contract to  
NASA Pasadena Office  
(NPO-11849)

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## ANALYSIS OF MULTILAYERED FIBER COMPOSITES

A multilevel analysis computer program has been developed which efficiently predicts the structural response of multilayered fiber composites.

The multilevel analysis consists of: (1) micromechanics theories for the single ply thermoelastic properties and stress-limit as functions of constituent materials properties and the particular fabrication process; (2) the combined stress-strength criterion of the single ply, and; (3) the multilayered composite structural response and analysis, where the interply layer effect are taken into account.

The inputs to the program are constituent material properties, factors representing the fabrication process, and composite geometry. The program performs the micromechanics, macromechanics, and laminate analysis of fiber composites. The outputs are various ply and composite properties, the composite structural response (accounting for bending, stretching, coupling, etc.) and the composite stress analysis results, including the results of the combined stress-strength criteria. The program can be used efficiently as a package in complex-structure analysis, finite-element methods, buckling and vibration studies, and structural syntheses. Sample trial cases are included to aid in the use of this program.

The program has been used successfully in the analysis of various fiber matrix multilayered com-

posites. It has proved to be efficient in structural synthesis of multilayered thornel/epoxy composite plates, in buckling studies in simply supported multilayered fiber-composite plates, and in computing the lamination residual stresses in angle ply composites. The program documentation includes the mechanics of using the program and the equations used in the program. Correlation coefficients for new composite systems are described, and possible extensions for temperature-dependent properties, material non-linearities, and failure load envelopes are included.

This program is written in FORTRAN IV for use with the IBM-7094 computer.

The following documentation may be obtained from:

National Technical Information Service  
Springfield, Virginia 22151  
Single document price \$3.00  
(or microfiche \$0.95)

Reference: NASA TN-D-7013 (N71-20530),  
Computer Code for the Analysis of Multi-  
layered Filamentary Composites -- User's  
Manual

Source: C. Chamis  
Lewis Research Center  
(LEW-11347)

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## TOLERANCE ANALYSIS

This digital computer program can be used to determine tolerance values of an end-to-end signal chain or flow path, given a preselected probability value. It can define the required tolerances in procurement or test specifications. The technique should be useful in the synthesis and analysis phases of the subsystem design processes.

The tolerance analysis program takes known circuit element hardware test data, such as a histogram or a specified nominal value with an associated set of limits, and statistically sums the probability density functions (PDF's) of the individual circuit elements into an overall PDF for the complete end-to-end sig-

nal path. From the overall PDF, the program computes a set of limits containing the desired preselected probability value. This program does not assume the nature or shape of the individual building block or circuit element PDF.

This program is written in FORTRAN IV and Binary for use with the IBM-360 computer system.

Source: H. K. Watson of  
North American Rockwell Corp.  
under contract to  
Manned Spacecraft Center  
(MSC-17487)

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## METABOLIC BALANCE ANALYSIS PROGRAM

This program calculates the life support consumables requirements and the related waste removal by analysis of a proposed 28-day diet. The specific diet supplies the quantity of food required to supply the necessary metabolic energy, the quantity of water needed to reconstitute the dried foods and provide supplementary body requirements, the amount of oxygen required to support metabolism, and the amount of carbon dioxide generated. These factors in turn determine the quantities of other body wastes generated.

The total energy consumed is accounted for by equations representing the breakdown of foodstuffs into carbohydrates, fats, and proteins. These energy equations are modified to account for the digestive materials and indigestible crude fibers present in each unit of foodstuff. Equations are also formulated to simulate the following functions: digestive efficiency,

intestinal flow, vitamin and mineral needs, water intake, solid waste losses, and respiratory exchange ratio.

This program has possible applications in biological research and education, extended manned space programs, and other life support analysis programs. Potential diets can be analyzed and the results used to verify conformance of diet to specifications, adequacy of diet for supplying needed metabolic energy, and life support consumables and waste management requirements.

This program is written in FORTRAN IV for use with the CDC-6500 computer system.

Source: J. Rombach of  
Martin-Marietta Corp.  
under contract to  
Marshall Space Flight Center  
(MFS-21237)

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